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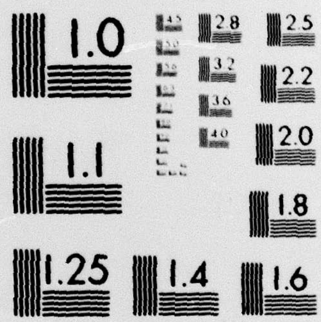

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Report SAM-TR-79-39

MEASURING RIGHT VENTRICULAR PRESSURE IN CONSCIOUS G-STRESSED MINIATURE SWINE

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December 1979

Final Report for Period 1 January 1979 - 30 June 1979

Approved for public release; distribution unlimited.

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

NOTICES

This final report was submitted by personnel of the Biodynamics Branch, Crew Technology Division, and Surgical Support Branch, Veterinary Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7930-12-21.

The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act of 1970 and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

This technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A surgical technique was developed, for conscious miniature swine, which allowed a Millar pressure transducer to be passed through a permanently placed catheter in the cranial vena cava via the external jugular vein. The recordings of central venous, right atrial, and right ventricular pressures were easily obtainable in fully conscious ambulatory animals. Our experience with this technique demonstrated that these pressure measurements could be monitored even when the animal was subjected to severe stress, such as $+10G_z$ to $-6G_z$, on a centrifuge, having the capability of continuous data collection.

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MEASURING RIGHT VENTRICULAR PRESSURE IN CONSCIOUS G-STRESSED MINIATURE SWINE

INTRODUCTION

The swine has become very useful in many areas of biomedical research (1,2). In the specific area of acceleration research, the miniature swine is particularly important as a human model because of several similarities to man: (a) similar coronary vasculature; (b) similar heart-to-eye distance; (c) similar tolerances to $+G_z$ acceleration; and (d) the ability to perform spontaneous straining maneuvers analogous to those used by aviators to maintain vision and consciousness while pulling high $+G_z$ during aerial combat maneuvers. This animal, therefore, provides an excellent model for invasive investigation of the stressful and possibly hazardous effects of head-to-foot ($+G_z$) acceleration. The application of the results of these studies should thus afford maximum protection to aircrewmen exposed to high $+G_z$ in the future.

A specific drawback in using miniature swine for biomedical research is the lack of an easily obtainable vascular access. In this animal, the posterior pinna veins of the ears constitute the only venous access normally used for catheterization. Others have described diverse methods for insertion and long-term implantation (3) of catheters for blood sampling and injections. We have had similar success in long-term (60 - 9[illegible] days) maintenance of patent Silastic rubber catheters for similar purposes, including injection of radioactive microspheres.

We are currently investigating the effects of $+G_z$ acceleration stress on cardiac (4) and pulmonary function (5). A desirable part of this effort was to measure right ventricular pressures in conscious miniature swine during $+G_z$ stress. Due to the possible effects of thoracic surgery on pulmonary mechanics and function, we devised a technique which would allow these measurements, in conscious animals, and not require thoracic surgical manipulation.

This report presents a technique which allows the introduction of a Millar pressure transducer ~~(Catheter PC-350, 5 Fr)~~[1] into the right cardiac chambers, via a chronically implanted venous catheter, in conscious animals. The transducer can then be secured, and pressures in the right ventricle can be measured in conscious animals during exposure to various stressful environments. Since neither analgesia nor anesthesia is needed before, during, or after transducer placement, measurements can be made in (fully) unanesthetized animals.

1/ Millar Instruments, Inc., P.O. Box 18227, Houston, TX 77023.

MATERIALS AND METHODS

Surgical Procedures

The miniature swine utilized in acceleration research at the USAF School of Aerospace Medicine are a Pitman-Moore strain.[2/] All animals are maintained under veterinary supervision, in individual runs, at all times. Surgical techniques similar to those previously reported (3) are used for insertion of the implanted catheters. All procedures were carried out using sterile techniques. Dow Corning Silastic medical grade rubber tubing (o.d. 3.18 mm, and i.d. 1.58 mm)[3/] was implanted for blood withdrawal or selective injection. At the same implantation site, a larger polyethylene catheter (o.d. 3.49 mm, and i.d. 2.67 mm)[4/] was also inserted, for subsequent introduction of the pressure transducer (Figs. 1 and 2). With the pig lying on its right side, the topographic landmark for the skin incision is a straight line between the mandibular angle of the jaw and the point of the shoulder. The dissection is continued deeper in a straight ventral (straight down) direction, so that the external jugular vein may be located and isolated. The vein was ligated cranially with 2-0 silk, and a second 2-0 ligature silk was passed twice around the caudal end to control retrograde hemorrhage. After a small longitudinal incision was made in the vein, the catheters were introduced and advanced to the point that the tips would be in the desired location (cranial vena cava). The second silk ligature was then tied, snugly enough to prevent bleeding, around the catheters without compressing or occluding them. A third silk ligature was similarly placed a short distance from the second one; then these two ligatures were used to anchor the two catheters to the vein and prevent their expulsion. This anchoring was accomplished by tying a short loop into the ligature, passing each free end around one catheter from opposite directions, and then tying snugly without occluding the catheter. After each tie around a catheter, its patency was determined by aspirating with a heparinized-saline-filled syringe, a three-way stopcock, and a blunt needle attached to the end of each catheter. A gauze sponge was then wrapped around each catheter, the catheters were cross-clamped lightly near the neck, and the syringes and needles were removed.

By digital palpation, the edges of the lateral processes of the cervical vertebrae could be identified, and the catheter ends could be tunneled through the subcutaneous tissue just lateral to the vertebrae and exteriorized on the dorsum of the neck. This procedure was accomplished by means of a large, straight, stainless-steel needle with a double loop of umbilical tape tied through the eye. The end of the catheter, which was placed through the loop and doubled over, could be pulled to the dorsum of the neck. Changes in direction of the catheters were kept to gentle curves rather than sharp angular turns. Finally, the syringes were reattached, and the catheter patency rechecked. After closure of the lateral neck incision, the catheters were flushed, filled with straight heparin, and stoppered with sterile metal plugs.

2/ Vita Vet Laboratories, Inc., Box 587, Marion, IN 46952.

3/ Dow Corning, Medical Products Div., P.O. Box 1592, Midland, MI 48640.

4/ Becton, Dickinson and Company, Rutherford, NJ 07070.

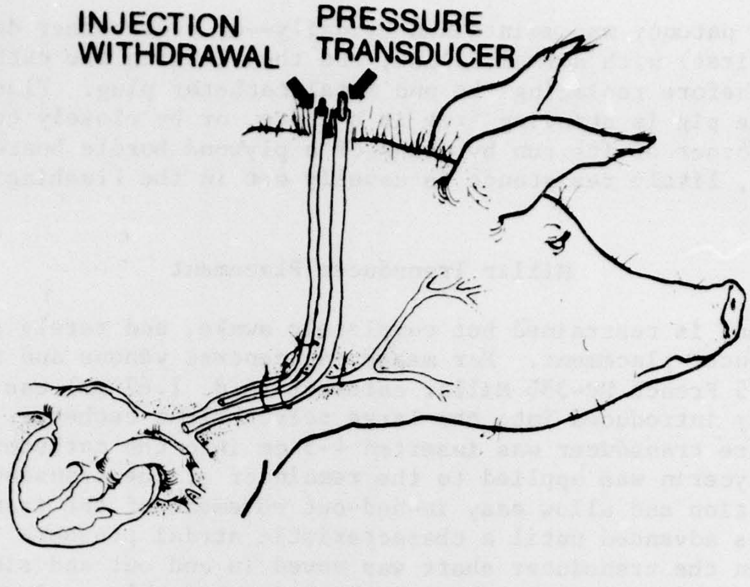

Figure 1. Surgical placement of chronically implanted Silastic and polyethylene catheters into the miniature swine vasculature.

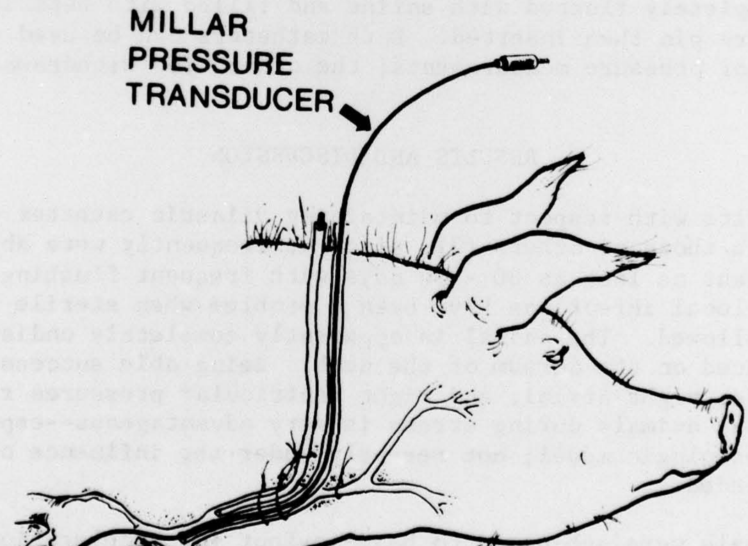

Figure 2. Placement of the Millar pressure transducer through the polyethylene catheter into the right ventricle of the miniature swine for measurement of right ventricular pressures.

Catheter patency was maintained by daily--or every other day--flushing (withdrawal first) with normal saline, and then leaving the catheter filled with heparin before replacing the end metal catheter plug. Flushing may be done while the pig is standing free in a crate, or by closely confining the animal in a corner of its run by means of a plywood hurdle board. With either method, little resistance is usually met in the flushing procedure.

Millar Transducer Placement

The animal is restrained but completely awake, and rarely struggles during transducer placement. For measuring central venous and right heart pressures, a 5 French PC-350 Millar catheter (o.d. 1.67 mm) was calibrated and then carefully introduced into the large polyethylene catheter. After the Millar pressure transducer was inserted 4-5 cm into the catheter, a thin coat of sterile glycerin was applied to the remainder of the transducer shaft to decrease friction and allow easy in-and-out movement of the transducer. The transducer was advanced until a characteristic atrial pressure trace was obtained, then the transducer shaft was moved in and out and simultaneously rotated in an attempt to pass through the tricuspid valve. In our experience, a 10-min period is usually enough for successful placement of the transducer in the right ventricle. When the transducer was in the desired location, the polyethylene tubing was tied snugly to the transducer shaft with umbilical tape to prevent blood loss caused by increased pressure development as a result of grunting during stress. After withdrawal of the transducer, the catheter should be completely flushed with saline and filled with heparin, and the sterile closure pin then inserted. Both catheters can be used at the same time: one, for pressure measurements; the other, for withdrawal or injection.

RESULTS AND DISCUSSION

Our results with respect to maintaining Silastic catheter patency are in agreement with those of others (3), since we frequently were able to keep catheters patent as long as 60 - 90 days with frequent flushing. Neither systemic nor local infections have been a problem when sterile flushing techniques are followed. The animal is apparently completely undisturbed by the catheters placed on the dorsum of the neck. Being able successfully to measure central venous, right atrial, and right ventricular pressures repeatedly in fully conscious animals during stress is very advantageous--especially when a conscious physiologic model, not recently under the influence of pharmacologic agents, is needed.

Our animals were subjected to head-to-foot $+G_z$ acceleration stress up to $+10G_z$, and foot-to-head $-G_z$ acceleration stress to $-6G_z$, without loss or reduction in pressure signal ouput. During the $+G_z$ stress, the animal performs a vigorous straining maneuver and, in addition, is physically compressed into the formfitted fiberglass couch in which it rides on the centrifuge. This process represents considerable movement without loss of continual data collection. The method would be specifically useful in measuring right-sided pressures during other types of stress, such as treadmill testing, when a nonviolated thoracic cavity is desired.

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